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International Business
Bachelor's Thesis
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ABSTRACT OF
BACHELOR'S THESIS

Author: Ville Hotti

Title of thesis: The Effects of Quantitative Easing on Government Bond Market Liquidity

Date: 5 April 2021

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Supervisor: Roman Stepanov

Objectives

The objective of the research is to analyze the impact of quantitative easing programmes conducted by the Federal Reserve from 2009 till present on US Treasury market liquidity. More specifically, the objective is to determine how the spotlight and scarcity effects affect liquidity as the relative and absolute share of the Federal Reserve's US Treasury holdings changes. Another objective is to find a level of relative US Treasury holdings where liquidity no longer improves and starts to deteriorate.

Summary

This quantitative paper analyses US 10-year Treasury's bid-ask spreads and the Federal Reserve's US Treasury holdings using regression analysis. Bid-ask spreads are used to measure liquidity and the Federal Reserve's US Treasury holdings are used to measure the size of the quantitative easing programmes.

Conclusions

This paper concludes that the second quantitative easing programme improved liquidity, the third had no effect and the fourth worsened liquidity after the initial

improvement. Around 15% seems to be the share of US Treasuries the Federal Reserve can hold without worsening liquidity conditions. The spotlight and scarcity effects had an expected effect as the spotlight effect improved liquidity initially and the scarcity effect caused liquidity to worsen as the Federal Reserve increased its US Treasury holdings.

Keywords: Quantitative easing, US Treasury market, Liquidity, Illiquidity

Language: English

Grade:

TABLE OF CONTENTS

1. INTRODUCTION

1.1 Background

Since the 2008 financial crisis, major central banks have conducted several quantitative easing programs in efforts to prevent adverse financial shocks, boost inflation, promote lending, and ultimately investing. They have done this through asset purchases, buying mortgage-backed securities, government- and corporate bonds, and even exchange-traded funds in Japan. Another role of these purchases has been clearing toxic assets from bank's balance sheets, improving their financial stability. This has led to the massive growth of central bank balance sheets. For example, the Federal Reserve's Treasury holdings have grown about 1000% from about $475 000 million since February 2009 to $4,8 trillion in February 2021 (Federal Reserve Bank of St. Louis, 2021). This means that central banks are restricting the number of available treasuries and thus boosting their valuations. Central banks' presence in the treasury markets is also lowering risk premiums as investors trust them to intervene in the markets if volatility starts to get out of control.

There are also problems created by quantitative easing. One of these issues is worsening liquidity conditions in the government bond markets which has been an issue especially in Japan as the Bank of Japan's relative bond holdings are larger than other central banks' holdings. This issue emerges as the amount of publicly traded government bonds declines due to central bank purchases. This negatively impacts the depth of the market, reducing the government bond market's ability to absorb large bids and offers. This is a serious issue as having a well-functioning treasury market is critical for the health of the financial system.

1.2 Research problem

Global financial markets have increasingly become dependent on stimulus from central banks and this has forced them, including the European Central Bank, to buy an increasing number of assets to keep the financial markets stable. This has caused liquidity issues, especially in Japan, as there are not enough bonds available for deep and liquid markets to exist. Central bankers are facing a conflict between the need to support the markets with quantitative easing and the need to limit the portion of available assets they hold so they do not cause too severe market distortions and liquidity issues.

To make good policy decisions, it would be useful to know how much a central bank can buy without causing liquidity issues. The current literature on this is lacking and the topic should be studied more extensively as central banks will likely keep using asset purchases as one of their main monetary policy tools.

1.3 Research questions

1) Have the Federal Reserve's quantitative easing programs improved or worsened liquidity conditions in the US Treasury markets?
2) Has the effect of quantitative easing on liquidity changed as the Federal Reserve's share of available bonds held has grown?

1.4 Research objectives

The objective of this paper is to analyze how the Federal Reserve's quantitative easing programs have affected liquidity conditions in the US Treasury markets. Specifically, the aim is to identify if the liquidity conditions have started to deteriorate after a certain threshold of the Federal Reserve's

relative treasury holdings had been passed. This threshold would be the point where the negative scarcity effect outweighs the positive spotlight effect. The relationship between these two effects provides the basis for the analysis in this paper.

The outcome of this study provides insights on quantitative easing's expected liquidity effects for bond investors, policymakers, and other regulators as well as an up-to-date review of the current state of liquidity after the COVID-19 related asset purchases.

2. LITERATURE REVIEW

This literature review's purpose is to provide some background on the reasons for quantitative easing and the effects on government bonds it has had. The most appropriate ways to measure liquidity in the government bond market are also discussed and relevant theories that explain the effects of large-scale asset purchases on liquidity in the government bond market are reviewed.

The literature on quantitative easing's liquidity effects is inconclusive, some seeing negative liquidity effects, especially in Japan, some seeing positive liquidity effects in Japan, Europe, and the US among others, and few found no statistically significant effects on liquidity. To explain this, two effects of quantitative easing are relevant: scarcity effect and spotlight effect. Great attention is paid to these two effects as multiple publications on bond market liquidity have identified them as highly important for liquidity.

One of the issues is measuring liquidity as there are no universally used ways to measure liquidity. There are multiple ways to approximate liquidity conditions in financial markets, including bid-ask spreads, depth of the market, and liquidity premiums. There are also attempts at creating liquidity

scores that use multiple data points to approximate liquidity conditions in the government bond market.

2.1 Effects of quantitative easing on government bond yields

The biggest and most obvious effect of large-scale asset purchases is the price appreciation of those assets. According to the law of supply and demand, if the quantity available declines, the equilibrium price goes up. In the case of quantitative easing, a central bank greatly boosts demand for the assets and simultaneously restricts the amount available. This creates perfect conditions for price appreciation as both the demand- and supply curves move favorably. This appreciation has been documented by Hubert (2020). He finds that quantitative easing done by the European Central Bank is effective at reducing sovereign bond yields, and thus boosting their valuations, after controlling for four categories of fundamentals: macroeconomic, international, financial, and expectations. He claims that the effect is bigger for Spain and to a lesser extent Italy compared to France and Germany, meaning that quantitative easing is 'effective at mitigating the disruption created by the sovereign debt crisis in the transmission of monetary policy across Eurozone countries' (p. 1202). He also concludes that most of the price movement happens right after the policy announcement with the open market operations having an additional effect.

Blattner and Joyce (2016) come to similar conclusions in their analysis as they analyze quantitative easing's effect on the government bond term structures of Spain, Italy, France, and Germany. Their data shows that the Public Sector Purchase Programme (PSPP) was effective at lowering yields across the term structure with long duration bonds seeing the biggest yield declines and lesser effect over time (Figure 1). Blattner and Joyce (2016) also claim there is evidence that quantitative easing's effects are transmitted to the broader economy via the yield curve. This means that the programme stimulated the economy by lowering yields.

Figure 1 below shows quantitative easing's predicted effects on 2-,5-, and 10-year yields during the Public Sector Purchase Programme between 2015 and 2017.

Figure 1: Changes in term structures (Blattner & Joyce, 2016)

Table 4. Predicted impact of the PSPP on the term structure and economy
(yields in basis points; output gap and inflation in percentage points)

	Term structure			Output gap	Inflation
	2-year	5-year	10-year		
2015	-8	-19	-30	0.2	0.1
2016	-5	-11	-18	0.2	0.3
2017	-3	-7	-12	0.0	0.2

Schlepper, Hofer, Riordan and Schrimpf, (2020) focus on the interdealer market in their analysis. They use both high- and low-frequency data to analyze quantitative easing's effect on government bond market functioning. They find that asset purchases conducted by the European Central Bank have 'a direct (high-frequency) impact on bond prices in the interdealer market' (p. 218). Their analysis shows that the price impact of an asset purchase is greater when liquidity conditions are poor. They also find that the price impact remains at the daily frequencies, which, according to Schlepper, Hofer, Riordan, and Schrimpf, (2020), 'provide evidence not only that QE policies have an impact on the announcement but also that the implementation of these policies has important effects on the market' (p. 218)

2.2 Measuring treasury market liquidity

There are many different approaches to estimate liquidity conditions in financial markets with the approaches being fairly similar across asset classes. Some researchers have created tools for tracking liquidity that have

several components that correlate with liquidity conditions. One of these liquidity scores was created by Choudhry (2010). He uses 14 different components with 3 different weights, including bid-ask spreads, market size, and the level of FTSE100 to measure liquidity in the gilt market. He suggests that this tool would be useful for obtaining a measure of relative liquidity in any stock or bond market, supporting the claim that liquidity can be measured with similar metrics across asset classes.

2.2.1 Bid-ask spread

The bid-ask spread is useful for measuring and tracking liquidity in the U.S Treasury market as concluded by Fleming (2001). He states that bid-ask spreads correlate strongly with more sophisticated price impact (liquidity) measures. Fleming (2001) also claims that compared to bid-ask spreads, other popular proxies like quote size, trade size, and the on-the-run/off-the-run yield spreads correlate only modestly with liquidity conditions.

Bid-ask spreads are commonly used to measure liquidity in the literature, for example by Christensen and Gillan (2013), Iwatsubo and Taishi (2018), Pelizzon, Subrahmanyam, Tobe, and Uno, (2018), as well as Schuster and Uhrig-Homburg (2012).

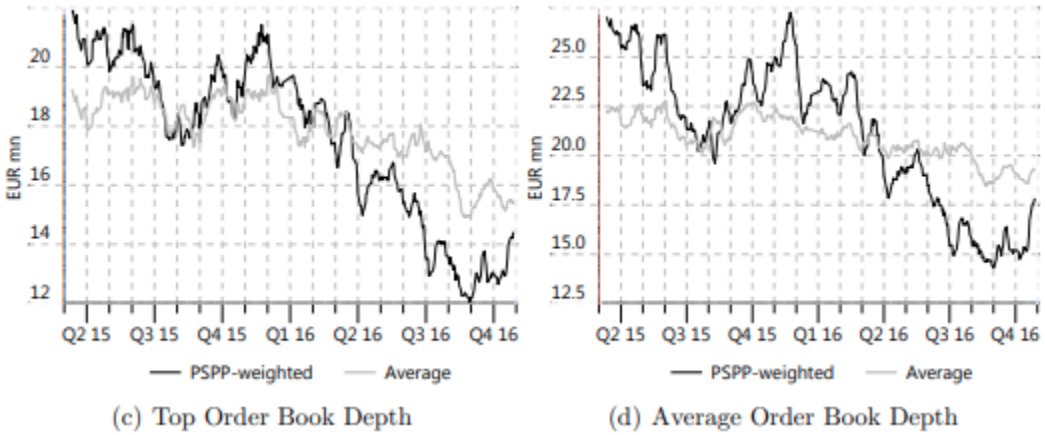
Corwin and Schultz (2012) have created a formula that estimates bid-ask spreads from daily high and low prices. They claim that the spreads calculated with the formula have a correlation of 0,9 with the actual spreads and ‘the standard deviation of high-low spread estimates is one-fourth to one-half as large as the standard deviation of estimates from the popular Roll (1984) covariance spread estimator’ (Corwin & Schultz (2012:719). This formula is widely used in the relevant literature as it allows researchers to use bid-ask spreads even though there may be insufficient bid-ask data available on certain securities.

Bid-ask spreads can be used to measure the liquidity of different bonds as well as across different asset classes as the trading of all kinds of securities is based on the same principle of bidding and offering. This makes the bid-ask spread a useful and versatile proxy for liquidity.

2.1.2 Depth of the market

Market depth (order book depth) is among the bid-ask spread one of the most important liquidity measures. It considers the number and size of standing offers and bids at various price levels around the equilibrium price. The bigger the amount and value of those bids and offers, the better the market can absorb large bids and offers without price movement, and thus the market is more liquid. Schlepper, Hofer, Riordan, and Schrimpf (2017) find that European Central Bank's Public Sector Purchase Program (PSPP) has affected order book depth negatively, leading to weaker liquidity conditions and wider bid-ask spreads (Figure 2). This conclusion is intuitive as it is logical that the number of bids and offers is lower as the number of available bonds in the market declines.

Figure 2: European bond market's order book depth (Schlepper, Hofer, Riordan, Schrimpf, 2017)



(c) Top Order Book Depth (d) Average Order Book Depth

Lennkh, Bartels, and Vasse (2019) analyze quantitative easing's effect on different investor bases' bond holdings. They found that central banks have

‘mostly displaced traditional domestic (not foreign) investor base of banks and institutional investors’ (p. 1). This supports the idea that having fewer investors in the market has had a negative effect on the depth of the market as volumes and trading frequencies are lower.

2.3 The term structure of bond liquidity

When studying bond markets and liquidity, taking the term structure of bond liquidity into account is important as changes in the yield curve tell a lot about the economy and affect many parts of the financial world. Another crucial role of government bond markets, especially the US Treasury market, is the indication of the risk-free rate. The liquidity of those markets is important because it affects efficient asset allocation and price discovery (Goyenko, Subrahmanyam, & Ukhov, 2011). Liquidity conditions affect term structures through liquidity premiums as investors demand additional value when they invest in illiquid assets.

They study liquidity in the US Treasury markets across maturities and both on-the-run and off-the-run bonds and find that while illiquidity increases across the whole yield curve during recessions, the increase is especially pronounced for short-term bonds. Goyenko, Subrahmanyam, and Ukhov, (2011) also find that while on-the-run illiquidity is mostly only affected by volatility, off-the-run illiquidity is affected by various economic factors. They conclude that ‘off-the-run illiquidity is the primary source of return forecastability (and thus, the liquidity premium) in the Treasury market’ (p. 137).

Since this paper is about quantitative easing, taking a look at bond market liquidity during crises is appropriate. Schuster and Uhrig-Homburg (2012) study illiquidity premiums during different economic environments and find that ‘the term structure of illiquidity premiums varies over time and is strongly dependent on the general financial and economic situation’ (p. 2). They also

find that illiquidity premiums only react significantly to fundamentals during crises.

2.4 Spotlight effect

The leading research paper on the spotlight effect is done by Pelizzon, Subrahmanyam, Tobe, and Uno (2018). In the paper, they analyze the effects of quantitative easing done by the Bank of Japan by focusing on two effects: spotlight effect and scarcity effect. They analyze both short- and long-term effects of Bank of Japan's open market operations on bond yields and liquidity.

The spotlight effect happens when a large unidirectional buyer, like a central bank, starts buying certain securities in the market. The effects of quantitative easing's spotlight effect include price appreciation and improvements in liquidity for the targeted assets (Pelizzon, Subrahmanyam, Tobe, & Uno, 2018). They claim that the spotlight effect's impact on liquidity is immediate as the presence of an aggressive buyer 'makes bond holders easy to sell their bonds to dealers' and 'increases competition among dealers which leads to tightening the bid-ask spread' (p. 1). However, this positive liquidity effect isn't long-lasting as 'an aggressive QE program can eventually worsen the market liquidity and increased market impacts in the sovereign bond market while it improves liquidity at the inception' (Pelizzon, Subrahmanyam, Tobe, & Uno, 2018:30).

Christensen and Gillan (2013) come to similar conclusions as they analyze the liquidity effects of Treasury Inflation-Protected Securities (TIPS) purchases during the Federal Reserve's QE2 program. Their regression analysis shows that TIPS purchases temporarily improved liquidity conditions, but the effect only lasted 'as long as QE purchases are ongoing and expected to continue' (p. 31). They only find liquidity effects in the targeted securities, suggesting that the improvements in liquidity conditions were due to the spotlight effect.

Pelizzon, Subrahmanyam, Tobe, and Uno (2018) also say that the spotlight effect does not take place before the actual purchases as the Bank of Japan does not announce the specific securities it intends to buy. Pelizzon, Subrahmanyam, Tobe, and Uno (2018) say: 'The list of target bonds that the BoJ announces for each auction includes more than 90% of the existing bonds in the targeted maturity bucket, but only one-third of the bonds on the target list are eventually purchased' (p. 3).

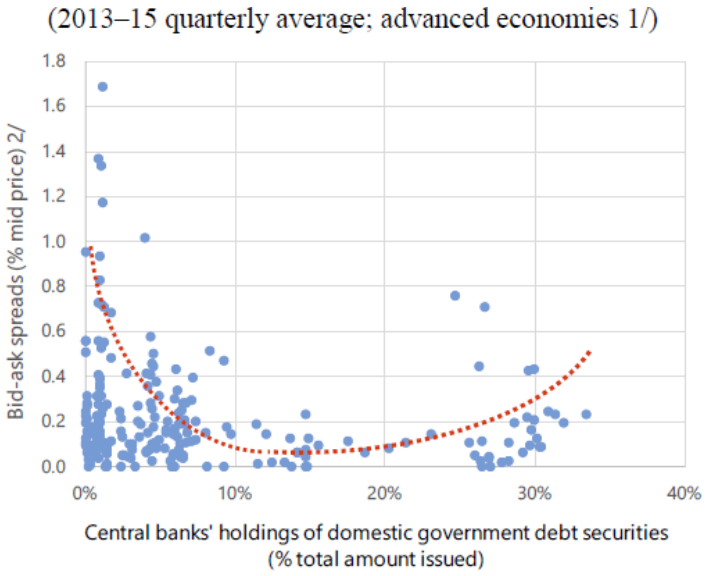
2.5 Scarcity effect

Pelizzon, Subrahmanyam, Tobe, and Uno (2018) say that Bank of Japan's large-scale asset purchases have, on top of the effect on yields and immediate positive effect on the liquidity of targeted assets, affected bond market liquidity negatively over the long-term. They argue that the reason for this is the scarcity effect, which happens when the available bond supply in the market shrinks, negatively affecting market functioning and liquidity conditions. This could explain why the literature on bond market liquidity is heavily focused on Japan, as the Bank of Japan holds the biggest share of sovereign bonds in the world (Fuijoka & Ito, 2020).

Han and Seneviratne (2018) come to similar conclusions on their research as they find 'strong evidence of the scarcity (flow) effects of QE in market liquidity' (p. 30). Using bid-ask spreads they find that quantitative easing had a significant negative effect on market liquidity across the Japanese government bond market. They also find evidence that the scarcity effect depends on the Bank of Japan's level of holdings. Their analysis shows that quantitative easing initially improved liquidity conditions, but the effect turned negative as the Bank of Japan's holdings exceeded certain thresholds (Figure 3). Bank of Japan was successful at mitigating adverse effects on liquidity conditions with its SLF program (Han. & Seneviratne, 2018), which is a repurchase agreement type lending facility that provides Japanese government securities to the market. This has since been confirmed by Hattori

(2019) as he states that having an auction system for older, less liquid bonds overwhelmingly improved liquidity condition in the Japanese government bond market. A need for a facility like that suggests that the Japanese bond market is suffering from illiquidity.

Figure 3: Market liquidity and Central Banks' Holdings of Domestic Sovereign Debt Securities, (Han & Seneviratne, 2018)



Sources: Arslanalp and Tsuda (2012); Bloomberg, L.P.; and IMF staff calculations.
1/ Advanced economies in the sample include Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Ireland, Italy, Japan, Netherlands, New Zealand, Portugal, Slovenia, Spain, Sweden, Switzerland, the United Kingdom, and the United States.
2/ Quoted bid-ask spreads are used for simplicity.

One of the interesting findings Pelizzon, Subrahmanyam, Tobe, and Uno (2018) discover was that against theoretical expectations, 'Illiquidity caused by scarcity amplifies the yield decline rather than adding to the illiquidity premium' (p. 0).

2.6 Importance of communication from the central banks

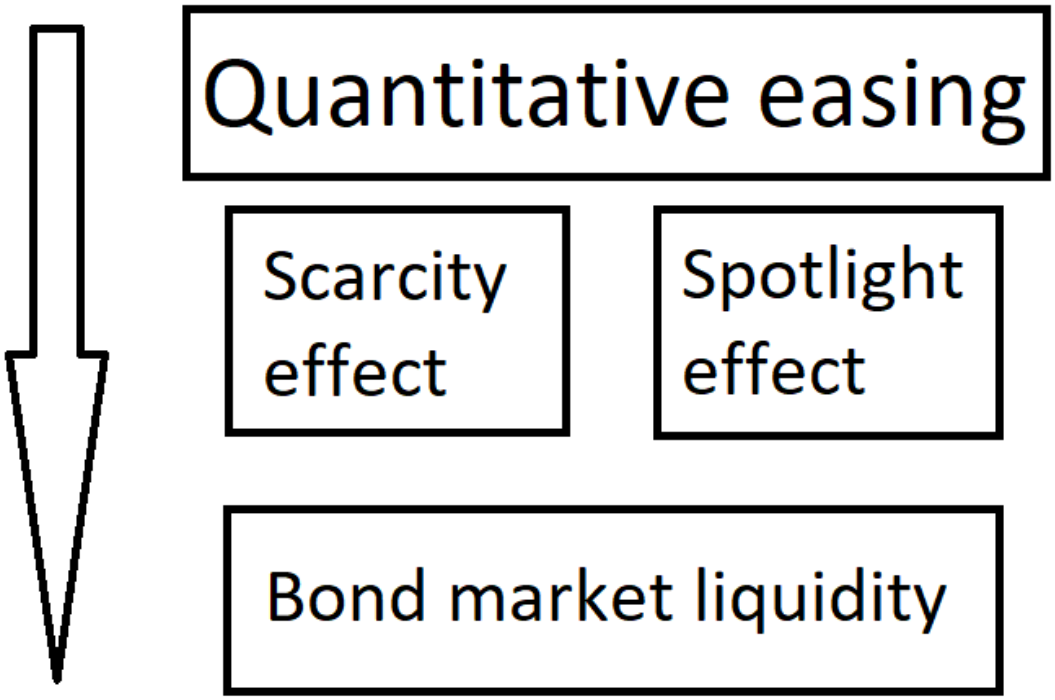
Forward guidance has become an important tool for central banks for setting market expectations for future monetary policy decisions and by doing so, reducing volatility and large price movements after the actual policy

announcements. Campbell (2019) studies the Federal Reserve's ability to manage expectations about future interest rates and finds that while not having perfect control over the expectations it remains an effective monetary policy tool. Campbell (2019) also says that miscommunication by a central bank 'feeds macroeconomic volatility and can challenge the central bank's ability to stabilize the economy' (p. 131).

Despite forward guidance grabbing the most attention, more subtle ways of communication are important for well-functioning markets as well. Iwatsubo and Taishi (2018) study the market liquidity effects the Bank of Japan's purchase policy change in April 2013 had. Among other changes, the Bank of Japan started to announce a broad purchasing pattern. They found that by easing investors' expectations on the timing and amount of future open market operations the Bank of Japan was able to significantly improve market liquidity. Iwatsubo and Taishi (2018) conclude that 'central banks' communication and transparency play an important role in large-scale government bond purchases in terms of market liquidity' (p. 474).

2.7 Conceptual framework

The purpose of this paper is to answer two questions. The first question being if the quantitative easing programs done by the Federal Reserve have improved or deteriorated liquidity conditions in the US Treasury market. The second question is if the quantitative easing's liquidity effects have changed as the Federal Reserve's relative share of bonds held has grown. The outcome of the analysis depends on if the negative scarcity effect has outweighed the positive spotlight effect.



3. RESEARCH

In this chapter, data is analyzed using regression and it is explained why these datasets were chosen. This analysis is quantitative as all of the data is strictly numerical and does not include opinions or other types of data with room for different interpretations.

3.1 Hypothesis

The hypothesis is that quantitative easing initially improves liquidity through the spotlight effect, which shows as tightening bid-ask spreads. After a certain threshold, the scarcity effect becomes dominant and liquidity starts to deteriorate and the bid-ask spreads start to widen.

The null hypothesis would then be that the Federal Reserve's US Treasury purchases have no impact on the US Treasury market's liquidity conditions.

3.2 Methodology

This paper attempts to find a correlation between the value of the Federal Reserve's US Treasury holdings and the US Treasury market's liquidity. According to Fleming (2001), bid-ask spreads are effective at approximating liquidity conditions in US Treasury markets. This is why the bid-ask spread of a 10-year on-the-run US Treasury's yield was chosen as a liquidity indicator.

A linear regression model was chosen as most appropriate even though the bid-ask spread is expected to create a U-shaped graph as a function of the Federal Reserve's US Treasury holdings. This is because one of the objectives is to find if the liquidity effect changes as the Federal Reserve's relative US Treasury holdings grow. By using a linear model and analyzing each quantitative easing programme individually it is possible to get a reasonably close approximation of each quantitative easing programme's impact on liquidity.

Reliability analysis will be done using the Gauss-Markov theorem. Five assumptions are tested. These are:

1. Linearity
2. Random
3. Non-Collinearity
4. Exogeneity
5. Homoscedasticity

3.3 Data collection

The data for this paper comes from the Federal Reserve of St. Louis (FRED), Bloomberg, and Investing.com. To analyze quantitative easing's effects on bond market liquidity, data on the US 10-year on-the-run bond's bid-ask spreads and the Federal Reserve's holdings of US Treasuries maturing in 5 to 10 years are analyzed using regression. The data is from the beginning of 2009 to 26.2.2021 and it covers all the quantitative easing programs conducted by the Federal Reserve to date. However, only data during quantitative easing programmes 1-4 is analyzed.

The bid-ask spread data on the US 10-year Treasury yield is used as an indicator of general liquidity conditions in the US Treasury markets. A maturity of 10 years was chosen because of its importance in the financial markets. The bid-ask spread is the dependent variable.

The Federal Reserve's holdings of US Treasuries with a maturity between 5 and 10 years is used as a proxy for quantitative easing. The Federal Reserve's total US Treasury holdings and its holdings of Treasuries with maturities between 5 and 10 years haven't always moved in tandem. This is due to changes in average maturities of purchased Treasuries. During and after quantitative easing programme 3 the Federal Reserve moved its focus on securities with maturities of over 10 years, causing its holdings of US Treasuries with maturities between 5 and 10 years to decrease during quantitative easing programme 3. Despite this, the Federal Reserve's holdings of US Treasuries with maturities between 5 and 10 years are used as this paper focuses its analysis on the spotlight effect. Unfortunately, data on the Federal Reserve's holdings of US 10-year Treasuries alone was unavailable.

3.4 Data analysis

Four periods between 2009 and 2021 are analysed: 13.3.2009-26.3.2010 (QE1), 29.10.2010-29.6.2012 (QE2), 1.4.2013-31.10.2014 (QE3), and 23.3.2020-26.2.2021 (QE4).

Quantitative easing programme 1

The first quantitative easing programme had no significant effect on bid-ask spreads as it was relatively small compared to latter programmes and focused on mortgage-backed securities instead of US Treasuries. During the programme, the Federal Reserve bought US Treasuries that were worth $300 Billion, out of which $114 Billion had a maturity between 5 and 10 years.

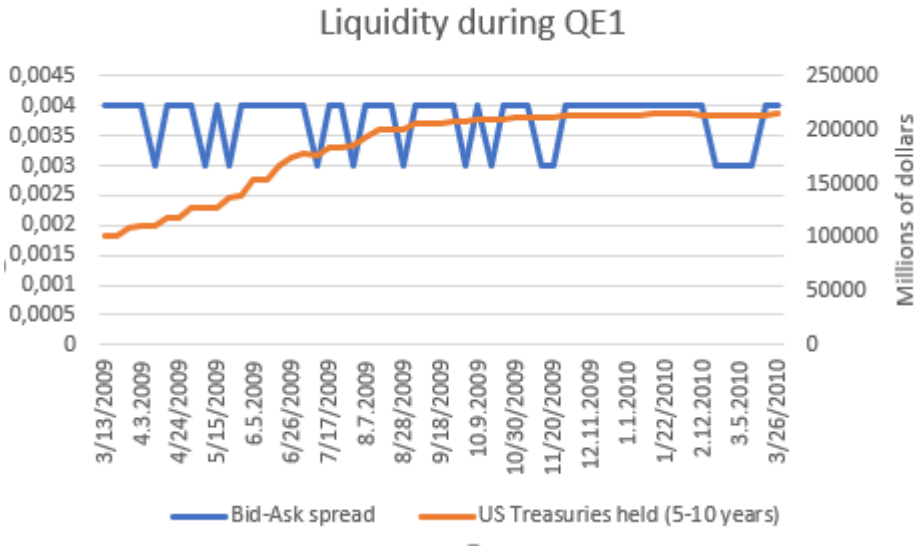


Figure 4: US 10-year Treasury's bid-ask spread and the FED's holdings of US Treasuries with maturities between 5 and 10 years (Quantitative easing programme 1), (Federal Reserve of St. Louis, 2021)

No statistically significant correlation was found using regression analysis as the p-value was 0,66. The 10-year bond's bid-ask spread stayed constant between 0,003 and 0,004 during the whole programme. One of the challenges with using bid-ask spreads is the lack of fine changes in the spread. Every

move in the spread is over 10%, leading to a situation where small changes in the independent variable don't show in the dependent variable.

SUMMARY OUTPUT								
Regression Statistics								
Multiple R	0,059875266							
R Square	0,003585047							
Adjusted R Square	-0,015215235							
Standard Error	0,000442952							
Observations	55							
ANOVA								
	df	*SS*	*MS*	*F*	*gnificance F*			
Regression	1	3,74149E-08	3,74149E-08	0,190691	0,664116			
Residual	53	1,03989E-05	1,96207E-07					
Total	54	1,04364E-05						
	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*ower 95,0%*	*pper 95,0%*
Intercept	0,003871721	0,000295255	13,11314074	2,86E-18	0,00328	0,004464	0,00328	0,004464
X Variable 1	-6,85298E-10	1,56933E-09	-0,43668198	0,664116	-3,8E-09	2,46E-09	-3,8E-09	2,46E-09

Figure 5: Regression Statistics for QE1

Quantitative easing programme 2

The Federal Reserve bought $872 billion in US Treasuries during this programme, out of which $502 billion had a maturity between 5 and 10 years. The chart below shows that while the effect was not immediate, the spread tightened as the Federal Reserve's Treasury holdings grew.

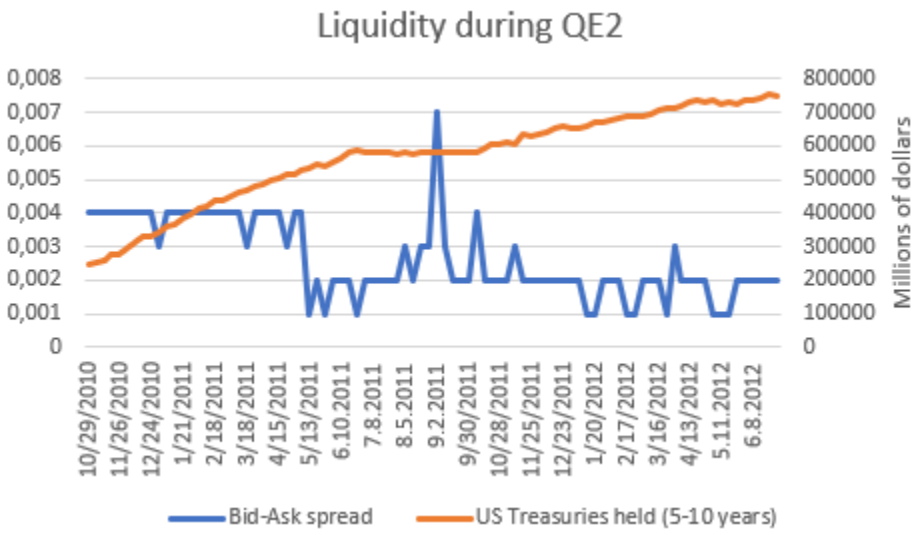
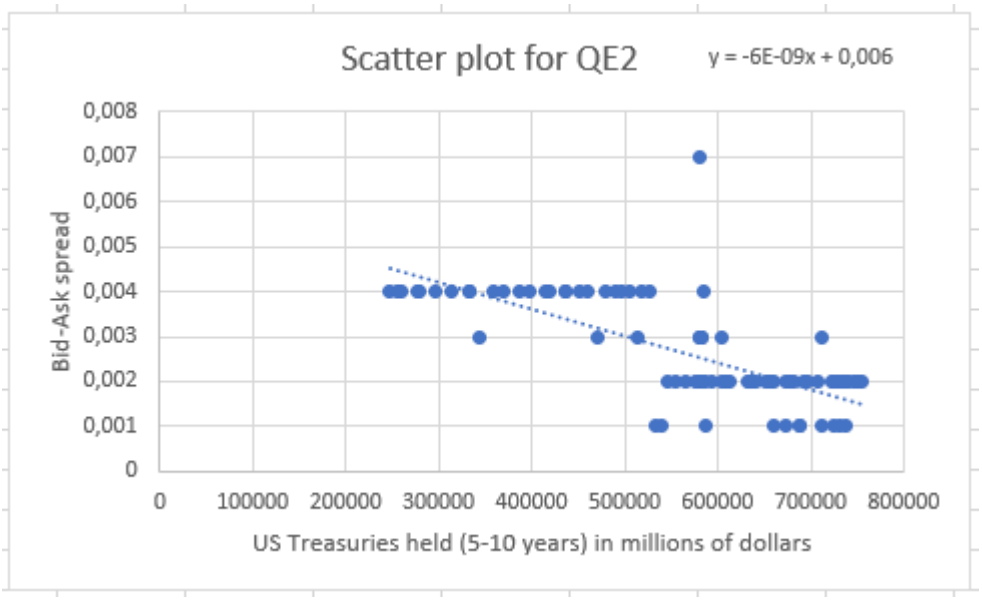


Figure 6 US 10-year Treasury's bid-ask spread and the FED's holdings of US Treasuries with maturities between 5 and 10 years (Quantitative easing programme 2), (Federal Reserve of St. Louis, 2021)

Out of the four programmes, the second one had the biggest impact on market liquidity as the 10-year bond's bid-ask spread tightened from 0,004 to 0,002 during the programme. Regression analysis suggests a statistically significant correlation with R Square being at 0,507. This means that about 51% of the move in the spread is due to the change in the Federal Reserve's Treasury holdings. This result can be considered reliable as the p-value is close to zero at 7,28*10^(-15).

As the R Square and P-value suggest statistical significance, reliability will be tested with the Gauss-Markov assumptions.



This scatter plot shows that the data is linear, though with considerable error terms. The data interval is weekly and there should be no sampling errors as data is used evenly from the whole period analyzed. Collinearity is not a problem as the two variables used are clearly not 100% correlated. This data could have some issues with exogeneity because illiquidity events in the US Treasury markets have forced the Federal Reserve to take action in the form of quantitative easing. This should not be a major issue because the Federal Reserve's quantitative easing programmes are mostly influenced by macroeconomic variables. The data seems to be homoscedastic because the points across the x-axis have a similar variance.

SUMMARY OUTPUT								
Regression Statistics								
Multiple R	0,712155918							
R Square	0,507166052							
Adjusted R Square	0,501435425							
Standard Error	0,000810477							
Observations	88							
ANOVA								
	df	*SS*	*MS*	*F*	*Significance F*			
Regression	1	5,81339E-05	5,81339E-05	88,50097	7,28294E-15			
Residual	86	5,64911E-05	6,56873E-07					
Total	87	0,000114625						
	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*ower 95,0%*	*pper 95,0%*
Intercept	0,005966069	0,000365508	16,32269691	4,49E-28	0,005239464	0,006693	0,005239	0,006693
X Variable 1	-5,91645E-09	6,28908E-10	-9,407495205	7,28E-15	-7,16668E-09	-4,7E-09	-7,2E-09	-4,7E-09

Figure 7: Regression Statistics for QE2

The regression equation thus is Y(bid-ask spread)=0,005966069-5,91645E-09*X(US Treasuries held (5-10 years) in millions of dollars)

Quantitative easing programme 3

The third quantitative easing programme had no impact on the 10-year bond's bid-ask spreads. There are two likely reasons for this. The first one being that the spread was extremely tight before the programme and didn't have space to move lower. The second reason is that during the quantitative easing programme 3 the Federal Reserve mainly bought Treasuries with maturities over 10 years. Even though the Federal Reserve's total US Treasury holdings grew roughly by $808 billion during the programme, its holdings of US Treasuries with maturities between 5 and 10 years fell by $136 billion. This means that there was no spotlight effect to improve liquidity.

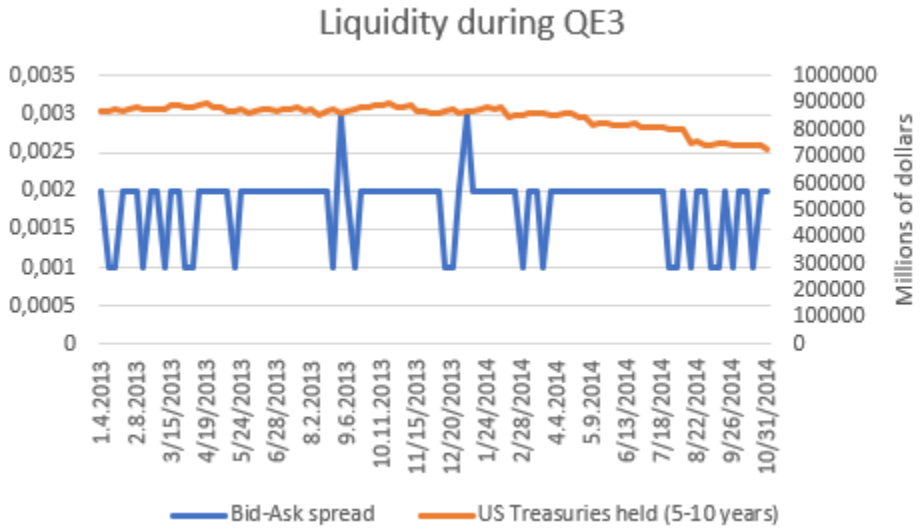


Figure 8: US 10-year Treasury's bid-ask spread and the FED's holdings of US Treasuries with maturities between 5 and 10 years (Quantitative easing programme 3), (Federal Reserve of St. Louis, 2021)

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0,160137376
R Square	0,025643979
Adjusted R Square	0,015278489
Standard Error	0,000439383
Observations	96

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	4,77619E-07	4,78E-07	2,473977	0,119104738
Residual	94	1,81474E-05	1,93E-07		
Total	95	1,8625E-05			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*ower 95,0%*	*pper 95,0%*
Intercept	0,000509387	0,000829697	0,613943	0,540736	-0,001137996	0,002157	-0,00114	0,002157
X Variable 1	1,53627E-09	9,76716E-10	1,572888	0,119105	-4,03028E-10	3,48E-09	-4E-10	3,48E-09

Figure 9: Regression Statistics for QE3

Quantitative easing programme 4

Analyzing any financial data from 2020 onwards is challenging due to COVID-19 and this is no exception. It is noteworthy that even though the Federal Reserve grew its US Treasury holdings by over $2,2 trillion between 23.3.2020 and 26.2.2021, it could not push bid-ask spreads down like during the quantitative easing programme 2. At this point, it is early to make a

judgment on whether or not the Federal Reserve's ability to improve liquidity with quantitative easing has diminished as no statistically significant correlations were found between liquidity and quantitative easing during quantitative easing programmes 3 and 4. Figure 10 still supports the claim that the scarcity effect has started to become dominant as the spreads seem to widen after the initial tightening. Another observation supporting the case for the scarcity effect is the lack of US Treasury market volatility during the COVID-19 crisis and quantitative easing programme 4. In practice, this means that the large fluctuations in the bid-ask spread during quantitative easing programme 4 can not be explained with higher volatility (figure 11). This further supports the case that the Federal Reserve's ability to improve liquidity has diminished and that further purchases would worsen the US Treasury market's liquidity.

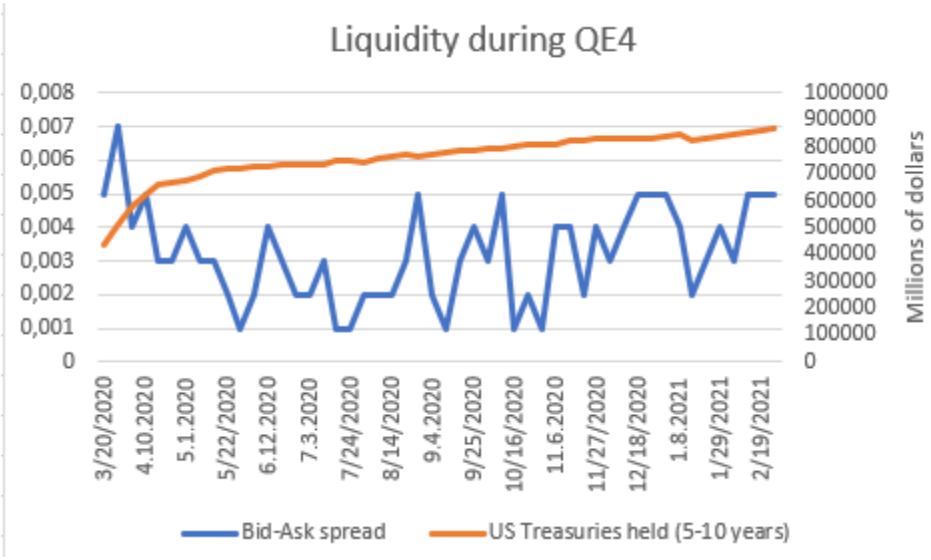


Figure 10: US 10-year Treasury's bid-ask spread and the FED's holdings of US Treasuries with maturities between 5 and 10 years (Quantitative easing programme 4), (Federal Reserve of St. Louis, 2021)

Figure 11: US Treasury market volatility index (Investing.com, 2021)

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0,132767641
R Square	0,017627246
Adjusted R Square	-0,002838853
Standard Error	0,001420404
Observations	50

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	1,73769E-06	1,74E-06	0,86129	0,358021407
Residual	48	9,68423E-05	2,02E-06		
Total	49	9,858E-05			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*ower 95,0%*	*pper 95,0%*
Intercept	0,004853271	0,001771309	2,739934	0,008602	0,001291815	0,008415	0,001292	0,008415
X Variable 1	-2,14699E-09	2,31342E-09	-0,92806	0,358021	-6,79844E-09	2,5E-09	-6,8E-09	2,5E-09

Figure 12: Regression Statistics for QE4

Below is a chart that shows the Federal Reserve's share of US Treasuries (Figure 13). This has been calculated by dividing the Federal Reserve's total US Treasury holdings with total US federal debt. The latest available data on US federal debt is from 3Q2020 and at that time the Federal Reserve held 16% of all US Treasuries. Han and Seneviratne (2018) found in their research that as the central bank's relative holdings grow from 0% to 10%, liquidity improves. Between 10% and 15% liquidity is at its highest level and after 15% to 20% it starts to deteriorate.

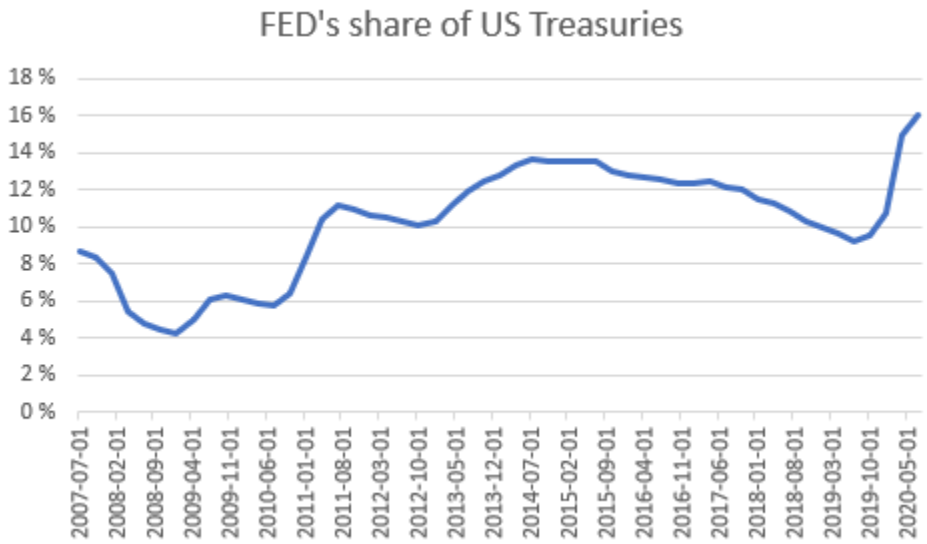


Figure 13: The Federal Reserve's relative US Treasury holdings, (Federal Reserve of St. Louis, 2021)

During quantitative easing programme 1, the Federal Reserve's relative US Treasury holdings grew from 4% to 6% which can be considered a minor change relative to later changes in holdings. It seems that this was not enough to tighten the bid-ask spread. During quantitative easing programme 2, the Federal Reserve's holdings grew substantially more, from 6% to around 11%. Han and Seneviratne (2018) find that liquidity improves until a central bank's relative holdings exceed 10%. Their research provides strong support for the claim that the improvement in liquidity during quantitative easing programme 2 was due to the Federal Reserve's quantitative easing programmes and the subsequent spotlight effect.

During quantitative easing programme 3, the Federal Reserve's relative holdings grew from 10% to 14%. According to Han and Seneviratne (2018) liquidity remains good but no longer improves at those levels. The results are consistent with their claims. This suggests that liquidity did not improve during quantitative easing programme 3 due to increasing negative scarcity effects. As the Federal Reserve's relative holdings grew from 10% to 16% during quantitative easing programme 4, spreads fluctuated between 0,001 and 0,005 after coming down from 0,007. It seems like that at the beginning of quantitative easing programme 4 intervention from the Federal Reserve

eased panic and led to tighter spreads. After the initial intervention, spreads started to widen towards 0,005 as the Federal Reserve's holdings exceeded 15%.

US 10-year Treasury's liquidity has followed the projected line Han and Seneviratne (2018) plotted in figure 3. This suggests that the size of the Federal Reserve's relative US Treasury holdings has an impact on US Treasury liquidity and that spotlight and scarcity effects drive changes in liquidity. Schlepper, Hofer, Riordan, and Schrimpf (2020) also found that central bank asset purchases likely caused deterioration in the Bund market. This strongly supports the hypothesis that after the initial improvement in liquidity, government bond purchases cause worse liquidity conditions.

4. FINDINGS

Results from the data analysis suggest that the spotlight effect improved liquidity conditions during quantitative easing programme 2. This is a similar result Christensen and Gillan (2013) came to in their research. It is also likely that the growth in the Federal Reserve's total US Treasury holdings helped to keep the spreads tight during quantitative easing programme 3 despite the lack of purchases of Treasuries with maturities between 5 and 10 years. During quantitative easing programme 4, the spread did not tighten to levels seen during the second and third programmes. This was likely due to the scarcity effect as the US Treasury market volatility has stayed subdued

Findings from the data analysis were consistent with research done by Han and Seneviratne (2018). There was a clear trend that emerged as the Federal Reserve's relative US Treasury holdings grew: the second programme had a large positive effect on liquidity, the third programme had no significant effect on liquidity and liquidity worsened during the fourth programme. This trend supports the argument that the scarcity effect causes worsening liquidity conditions as the central bank's relative bond holdings increase.

There are also limitations to the analysis as statistically significant correlations were found only when analyzing the second quantitative easing programme. Since the analysis on the scarcity effect relies mostly on visual interpretations and lacks robustness, comments on the scarcity effect and its impact on liquidity should be considered more as speculation rather than claims made by the author.

5. CONCLUSIONS

5.1 Main Findings

This study shows that the Federal Reserve's quantitative easing programmes have affected the US Treasury market's liquidity. The effect was initially positive as the Federal Reserve increased its relative US Treasury holdings from 6% to 11% during quantitative easing programme 2. During this period the spotlight effect was dominant over the scarcity effect. During the quantitative easing programme, 3 liquidity remained good but did not improve further as the Federal Reserve's relative holdings grew from 10% to 14%. Quantitative easing programme 4 failed to improve liquidity as the past programmes did as the Federal Reserve's relative holdings grew from 10% to 16%.

Results suggest that the scarcity effect becomes dominant as the Federal Reserve's relative holdings grow to around 15%. This means that while further asset purchases may support price stability, they would also cause further deteriorating in liquidity conditions.

5.2 Implications for International Business

These findings suggest that all US Treasury holders, most importantly institutional investors that utilize high-frequency trading, should prepare for less liquid US Treasury markets. In extreme scenarios similar to the Japanese situation other securities should be considered if liquidity is a critical property.

Policymakers should be very cautious about increasing the Federal Reserve's relative holdings further to keep the US Treasury market liquid and well-functioning. One of the key roles of US Treasuries is acting as collateral in various transactions and financing solutions. Adequate liquidity is critical for any collateral and if quantitative easing is taken to extremes, the Federal Reserve could risk compromising US Treasuries' position as the most preferred collateral. This could at least, in theory, lead to even worse liquidity as trading volumes would suffer.

5.3 Suggestions for Further Research

Repeating this study after the quantitative easing programme 4 is finished and the COVID-19 pandemic has been defeated could provide clearer results on the role the scarcity effect had on the lack of liquidity improvements during quantitative easing programme 4. Analysis of off-the-run bonds could also provide a more comprehensive understanding of the US Treasury market's liquidity conditions. Using the Federal Reserve's holdings of 10-year US Treasuries could provide more precise information on the impact of the spotlight effect.

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7. APPENDICES

Start Date	1.1.2009			
End Date				
	US GT10 Govt Bid Price	Ask Price		
Dates	PX_BID	PX_ASK	Securities held 5-10yrs	Securities held all
1.2.2009	2,372	2,369	97280	475718
1.9.2009	2,393	2,39	96462	475515
1/16/2009	2,322	2,319	97383	475322
1/23/2009	2,621	2,617	97338	475129
1/30/2009	2,844	2,84	97304	474982
2.6.2009	2,995	2,992	97278	474869
2/13/2009	2,893	2,889	99442	474756
2/20/2009	2,791	2,788	99416	474643
2/27/2009	3,017	3,013	100588	474619
3.6.2009	2,875	2,872	100598	474661
3/13/2009	2,894	2,89	100928	474704
3/20/2009	2,638	2,634	100938	474746
3/27/2009	2,761	2,757	109586	492330
4.3.2009	2,889	2,885	109906	508414
4.10.2009	2,926	2,923	110944	526103
4/17/2009	2,949	2,945	117956	534969
4/24/2009	2,994	2,99	118003	549046
5.1.2009	3,157	3,153	127410	560601
5.8.2009	3,289	3,286	127416	577091
5/15/2009	3,138	3,134	128320	583271
5/22/2009	3,453	3,45	137233	600142
5/29/2009	3,463	3,459	138134	606168
6.5.2009	3,832	3,828	153118	628690
6.12.2009	3,796	3,792	153325	638668
6/19/2009	3,785	3,781	166750	653193
6/26/2009	3,54	3,536	174540	663470
7.3.2009	3,502	3,498	177120	673500
7.10.2009	3,306	3,303	176253	684030
7/17/2009	3,647	3,643	183943	692726
7/24/2009	3,662	3,658	183950	695758
7/31/2009	3,483	3,48	184669	705331
8.7.2009	3,854	3,85	192654	728974
8/14/2009	3,573	3,569	200217	736086
8/21/2009	3,569	3,565	200238	744878
8/28/2009	3,449	3,446	201095	752841
9.4.2009	3,442	3,438	206041	757772
9.11.2009	3,351	3,347	206079	759803

9/18/2009	3,467	3,463	206625	765633
9/25/2009	3,322	3,318	207135	769160
10.2.2009	3,222	3,219	207140	769185
10.9.2009	3,384	3,38	210095	773460
10/16/2009	3,415	3,412	210312	773486
10/23/2009	3,494	3,49	210318	774561
10/30/2009	3,387	3,383	211085	776512
11.6.2009	3,501	3,497	211087	776520
11/13/2009	3,421	3,418	211684	776527
11/20/2009	3,369	3,366	211686	776535
11/27/2009	3,209	3,205	212649	776543
12.4.2009	3,476	3,472	212651	776554
12.11.2009	3,554	3,55	212766	776565
12/18/2009	3,541	3,537	212769	776576
12/25/2009	3,807	3,803	212771	776587
1.1.2010	3,839	3,835	213721	776595
1.8.2010	3,834	3,83	213723	776603
1/15/2010	3,678	3,674	214776	776611
1/22/2010	3,611	3,607	214778	776619
1/29/2010	3,588	3,584	215298	776614
2.5.2010	3,569	3,565	215293	776592
2.12.2010	3,697	3,693	213266	776571
2/19/2010	3,776	3,773	213261	776549
2/26/2010	3,615	3,612	214048	776553
3.5.2010	3,683	3,68	214057	776591
3.12.2010	3,704	3,701	214314	776629
3/19/2010	3,693	3,689	214323	776667
3/26/2010	3,851	3,847	215414	776705
4.2.2010	3,949	3,945	215415	776708
4.9.2010	3,886	3,882	215415	776711
4/16/2010	3,766	3,763	217540	776714
4/23/2010	3,813	3,809	217541	776717
4/30/2010	3,657	3,653	218232	776749
5.7.2010	3,429	3,425	218243	776792
5/14/2010	3,457	3,453	213483	776834
5/21/2010	3,242	3,238	213494	776877
5/28/2010	3,296	3,292	214177	776913
6.4.2010	3,206	3,202	214182	776932
6.11.2010	3,238	3,235	214308	776951
6/18/2010	3,223	3,22	214313	776970
6/25/2010	3,111	3,108	215211	776989
7.2.2010	2,981	2,977	215213	776997
7.9.2010	3,056	3,052	214982	777005
7/16/2010	2,925	2,922	214994	777013
7/23/2010	2,998	2,994	214996	777021
7/30/2010	2,909	2,905	215947	777019

8.6.2010	2,82	2,817	215945	777009
8/13/2010	2,675	2,672	216083	779549
8/20/2010	2,614	2,611	219689	784498
8/27/2010	2,648	2,645	220725	786283
9.3.2010	2,701	2,697	221947	789894
9.10.2010	2,795	2,792	225683	794646
9/17/2010	2,741	2,737	231228	805107
9/24/2010	2,609	2,605	232855	811669
10.1.2010	2,513	2,51	238962	819072
10.8.2010	2,396	2,392	238966	821156
10/15/2010	2,563	2,56	246208	832121
10/22/2010	2,558	2,554	246571	837848
10/29/2010	2,603	2,599	247169	842008
11.5.2010	2,534	2,53	254262	853041
11.12.2010	2,791	2,787	259205	873618
11/19/2010	2,875	2,871	276741	901238
11/26/2010	2,87	2,866	278938	917451
12.3.2010	3,009	3,005	297233	949612
12.10.2010	3,323	3,319	314299	967553
12/17/2010	3,332	3,328	332496	1007237
12/24/2010	3,397	3,393	332500	1016102
12/31/2010	3,297	3,294	342546	1030985
1.7.2011	3,328	3,324	359108	1062061
1/14/2011	3,327	3,323	368756	1079578
1/21/2011	3,408	3,404	386665	1114448
1/28/2011	3,325	3,321	396918	1138166
2.4.2011	3,64	3,636	414155	1167087
2.11.2011	3,633	3,629	418498	1190341
2/18/2011	3,584	3,58	435528	1213425
2/25/2011	3,416	3,412	436109	1236258
3.4.2011	3,494	3,49	452158	1266069
3.11.2011	3,406	3,402	460397	1280386
3/18/2011	3,271	3,268	469854	1305239
3/25/2011	3,443	3,439	478796	1333445
4.1.2011	3,446	3,442	488876	1358207
4.8.2011	3,581	3,577	496992	1374695
4/15/2011	3,412	3,408	505786	1402494
4/22/2011	3,394	3,391	513052	1413467
4/29/2011	3,29	3,286	517652	1441855
5.6.2011	3,15	3,146	525568	1466209
5/13/2011	3,172	3,171	532102	1495166
5/20/2011	3,147	3,145	546030	1519327
5/27/2011	3,075	3,074	539335	1532236
6.3.2011	2,988	2,986	554021	1554660
6.10.2011	2,971	2,969	565620	1575939
6/17/2011	2,946	2,944	580703	1601963

6/24/2011	2,865	2,864	585665	1617060
7.1.2011	3,184	3,182	581824	1624515
7.8.2011	3,029	3,027	582548	1630414
7/15/2011	2,908	2,906	579576	1634093
7/22/2011	2,964	2,962	582718	1638161
7/29/2011	2,798	2,796	577458	1640919
8.5.2011	2,561	2,558	580770	1644743
8.12.2011	2,257	2,255	576091	1647633
8/19/2011	2,065	2,062	581599	1648435
8/26/2011	2,193	2,19	579727	1652113
9.2.2011	1,993	1,986	579731	1655599
9.9.2011	1,921	1,918	583081	1658960
9/16/2011	2,05	2,048	583686	1663105
9/23/2011	1,835	1,833	583690	1664655
9/30/2011	1,917	1,915	583799	1671784
10.7.2011	2,08	2,076	583824	1668766
10/14/2011	2,25	2,248	593316	1670256
10/21/2011	2,221	2,219	607404	1678012
10/28/2011	2,319	2,317	603320	1654195
11.4.2011	2,035	2,033	612962	1668111
11.11.2011	2,059	2,056	604361	1675836
11/18/2011	2,012	2,01	633612	1664795
11/25/2011	1,966	1,964	631158	1672038
12.2.2011	2,035	2,033	636050	1675034
12.9.2011	2,063	2,061	640704	1673475
12/16/2011	1,849	1,847	655879	1684249
12/23/2011	2,026	2,024	660486	1672092
12/30/2011	1,878	1,876	650850	1663438
1.6.2012	1,96	1,958	655779	1650843
1/13/2012	1,865	1,864	659004	1651506
1/20/2012	2,026	2,025	673510	1661529
1/27/2012	1,893	1,891	672891	1662459
2.3.2012	1,924	1,922	677832	1660692
2.10.2012	1,988	1,986	680651	1667071
2/17/2012	2,003	2,002	688526	1656581
2/24/2012	1,977	1,976	687885	1661601
3.2.2012	1,976	1,974	691931	1659279
3.9.2012	2,03	2,028	697055	1659768
3/16/2012	2,296	2,294	707665	1663484
3/23/2012	2,233	2,232	711708	1664911
3/30/2012	2,212	2,209	711791	1669371
4.6.2012	2,056	2,054	721325	1681093
4/13/2012	1,984	1,982	729715	1672141
4/20/2012	1,965	1,963	739042	1667766
4/27/2012	1,937	1,935	732932	1667630
5.4.2012	1,88	1,879	737699	1665939

5.11.2012	1,839	1,838	723863	1656793
5/18/2012	1,724	1,723	730251	1656824
5/25/2012	1,74	1,738	723850	1656675
6.1.2012	1,454	1,452	738207	1664292
6.8.2012	1,637	1,635	738221	1660158
6/15/2012	1,579	1,577	745173	1663577
6/22/2012	1,676	1,674	754623	1666530
6/29/2012	1,647	1,645	749237	1666375
7.6.2012	1,551	1,549	754329	1662637
7/13/2012	1,489	1,488	757892	1648694
7/20/2012	1,458	1,457	767379	1651432
7/27/2012	1,548	1,546	770462	1649294
8.3.2012	1,565	1,563	779572	1652416
8.10.2012	1,659	1,657	766034	1646360
8/17/2012	1,812	1,81	773527	1637152
8/24/2012	1,688	1,687	778166	1639413
8/31/2012	1,55	1,548	785689	1648862
9.7.2012	1,67	1,668	790418	1650851
9/14/2012	1,868	1,866	799787	1646098
9/21/2012	1,755	1,753	804516	1648403
9/28/2012	1,635	1,634	809358	1652944
10.5.2012	1,745	1,743	814098	1653737
10.12.2012	1,658	1,656	823918	1659084
10/19/2012	1,765	1,763	823944	1646524
10/26/2012	1,747	1,745	826698	1645334
11.2.2012	1,716	1,715	836554	1651289
11.9.2012	1,608	1,606	836409	1656833
11/16/2012	1,582	1,58	844439	1650489
11/23/2012	1,692	1,69	844457	1646645
11/30/2012	1,616	1,616	846751	1653593
12.7.2012	1,623	1,622	856457	1660807
12/14/2012	1,703	1,701	866018	1658851
12/21/2012	1,765	1,762	866016	1656930
12/28/2012	1,703	1,701	862403	1666118
1.4.2013	1,901	1,899	866089	1676307
1.11.2013	1,869	1,868	871522	1688886
1/18/2013	1,843	1,842	874860	1696691
1/25/2013	1,951	1,949	871745	1710058
2.1.2013	2,017	2,015	874956	1717182
2.8.2013	1,952	1,95	881896	1728477
2/15/2013	2,003	2,002	880077	1736456
2/22/2013	1,964	1,962	872989	1749545
3.1.2013	1,843	1,841	876335	1761763
3.8.2013	2,044	2,043	880024	1769987
3/15/2013	1,991	1,989	887601	1784652
3/22/2013	1,927	1,925	894432	1794459

3/29/2013	1,85	1,849	882819	1805639
4.5.2013	1,714	1,713	886581	1814482
4.12.2013	1,723	1,721	889937	1825042
4/19/2013	1,707	1,705	897077	1836227
4/26/2013	1,665	1,663	882001	1847983
5.3.2013	1,74	1,738	885318	1854334
5.10.2013	1,899	1,897	867351	1864508
5/17/2013	1,952	1,951	871918	1877154
5/24/2013	2,01	2,008	875579	1883559
5/31/2013	2,13	2,128	863091	1898010
6.7.2013	2,174	2,172	866763	1906079
6/14/2013	2,131	2,129	872792	1918706
6/21/2013	2,533	2,531	879602	1928416
6/28/2013	2,488	2,486	870969	1942678
7.5.2013	2,741	2,739	876672	1952529
7.12.2013	2,584	2,582	879318	1961671
7/19/2013	2,486	2,484	886154	1970003
7/26/2013	2,564	2,562	869614	1982407
8.2.2013	2,598	2,596	874709	1993375
8.9.2013	2,58	2,578	855332	2001093
8/16/2013	2,827	2,825	871934	2012169
8/23/2013	2,816	2,815	875158	2023610
8/30/2013	2,787	2,784	864316	2033290
9.6.2013	2,936	2,934	867686	2041088
9/13/2013	2,886	2,885	874742	2052055
9/20/2013	2,736	2,734	881740	2062004
9/27/2013	2,626	2,624	880754	2076927
10.4.2013	2,647	2,645	887608	2086741
10.11.2013	2,689	2,687	889601	2095034
10/18/2013	2,58	2,578	896444	2106475
10/25/2013	2,511	2,509	882128	2117750
11.1.2013	2,624	2,622	885851	2125552
11.8.2013	2,75	2,748	891277	2137037
11/15/2013	2,705	2,703	867998	2150957
11/22/2013	2,745	2,743	871174	2163666
11/29/2013	2,746	2,744	858356	2169788
12.6.2013	2,857	2,855	864707	2185719
12/13/2013	2,866	2,865	871606	2197292
12/20/2013	2,89	2,889	877403	2208829
12/27/2013	3,002	3	864700	2208775
1.3.2014	2,998	2,995	867504	2212924
1.10.2014	2,86	2,858	868862	2220953
1/17/2014	2,821	2,819	874124	2231430
1/24/2014	2,717	2,715	883213	2243176
1/31/2014	2,646	2,644	880024	2252973
2.7.2014	2,685	2,683	885261	2261099

2/14/2014	2,745	2,743	847898	2267872
2/21/2014	2,733	2,731	855792	2278256
2/28/2014	2,649	2,648	854054	2288453
3.7.2014	2,79	2,788	859084	2295938
3/14/2014	2,656	2,654	861640	2305795
3/21/2014	2,744	2,743	864279	2311539
3/28/2014	2,723	2,721	853179	2320653
4.4.2014	2,723	2,721	855478	2326085
4.11.2014	2,627	2,625	859981	2335991
4/18/2014	2,723	2,721	860175	2341768
4/25/2014	2,664	2,662	847034	2350272
5.2.2014	2,586	2,584	849559	2354916
5.9.2014	2,625	2,623	820137	2361328
5/16/2014	2,525	2,523	824474	2367236
5/23/2014	2,534	2,532	826853	2370724
5/30/2014	2,478	2,476	814320	2378186
6.6.2014	2,589	2,587	816849	2385801
6/13/2014	2,605	2,603	816861	2391477
6/20/2014	2,607	2,605	821260	2396972
6/27/2014	2,536	2,534	808779	2404577
7.4.2014	2,64	2,638	811565	2408506
7.11.2014	2,518	2,516	810990	2410339
7/18/2014	2,483	2,481	811002	2413616
7/25/2014	2,467	2,466	800501	2420285
8.1.2014	2,494	2,493	800522	2422566
8.8.2014	2,422	2,42	802855	2427647
8/15/2014	2,341	2,34	751222	2431395
8/22/2014	2,404	2,402	755717	2435932
8/29/2014	2,345	2,343	742262	2436986
9.5.2014	2,46	2,459	742261	2440637
9.12.2014	2,612	2,611	746714	2446572
9/19/2014	2,576	2,574	746893	2448625
9/26/2014	2,529	2,528	739908	2451736
10.3.2014	2,436	2,434	741439	2454457
10.10.2014	2,282	2,28	741433	2455345
10/17/2014	2,195	2,194	742973	2459197
10/24/2014	2,27	2,268	744464	2461580
10/31/2014	2,337	2,335	729807	2461581
11.7.2014	2,299	2,298	729810	2461602
11/14/2014	2,322	2,32	700726	2461622
11/21/2014	2,312	2,31	700729	2461645
11/28/2014	2,166	2,164	693743	2461625
12.5.2014	2,308	2,307	693735	2461560
12.12.2014	2,083	2,082	693726	2461495
12/19/2014	2,164	2,162	693716	2461420
12/26/2014	2,252	2,25	686627	2461364

1.2.2015	2,112	2,111	686609	2461224
1.9.2015	1,947	1,945	685517	2461084
1/16/2015	1,839	1,837	693755	2460944
1/23/2015	1,799	1,797	693727	2460804
1/30/2015	1,642	1,641	687683	2460652
2.6.2015	1,958	1,957	687652	2460490
2/13/2015	2,052	2,05	658999	2460328
2/20/2015	2,113	2,112	658967	2460167
2/27/2015	1,995	1,993	649302	2460028
3.6.2015	2,243	2,241	649278	2459908
3/13/2015	2,116	2,114	649255	2459787
3/20/2015	1,932	1,93	649232	2459666
3/27/2015	1,963	1,961	637917	2459578
4.3.2015	1,841	1,839	637939	2459693
4.10.2015	1,949	1,947	637961	2459806
4/17/2015	1,867	1,865	637983	2459920
4/24/2015	1,91	1,909	638005	2460034
5.1.2015	2,115	2,114	632974	2460182
5.8.2015	2,15	2,148	633003	2460334
5/15/2015	2,144	2,142	591648	2460486
5/22/2015	2,211	2,209	591678	2460639
5/29/2015	2,123	2,121	586944	2460749
6.5.2015	2,409	2,408	586954	2460803
6.12.2015	2,394	2,392	586965	2460857
6/19/2015	2,259	2,258	586975	2460911
6/26/2015	2,474	2,473	574120	2460975
7.3.2015	2,384	2,382	574145	2461107
7.10.2015	2,399	2,397	569285	2461238
7/17/2015	2,349	2,347	569305	2461370
7/24/2015	2,264	2,262	569324	2461502
7/31/2015	2,182	2,18	563314	2461603
8.7.2015	2,164	2,162	563327	2461694
8/14/2015	2,199	2,198	525548	2461785
8/21/2015	2,038	2,036	525562	2461876
8/28/2015	2,182	2,181	522712	2461941
9.4.2015	2,126	2,124	522712	2461943
9.11.2015	2,19	2,188	522712	2461944
9/18/2015	2,135	2,134	522712	2461946
9/25/2015	2,164	2,162	514060	2461948
10.2.2015	1,995	1,993	514054	2461911
10.9.2015	2,09	2,088	514049	2461874
10/16/2015	2,035	2,033	514043	2461837
10/23/2015	2,088	2,087	514037	2461800
10/30/2015	2,144	2,142	512967	2461760
11.6.2015	2,327	2,325	512960	2461718
11/13/2015	2,268	2,266	500542	2461676

11/20/2015	2,264	2,262	500535	2461628
11/27/2015	2,222	2,22	494994	2461601
12.4.2015	2,271	2,269	494992	2461589
12.11.2015	2,129	2,127	494990	2461578
12/18/2015	2,206	2,204	494988	2461566
12/25/2015	2,243	2,241	494987	2461554
1.1.2016	2,271	2,269	489219	2461505
1.8.2016	2,117	2,116	489211	2461450
1/15/2016	2,036	2,035	488387	2461396
1/22/2016	2,054	2,052	488379	2461341
1/29/2016	1,923	1,921	485029	2461269
2.5.2016	1,837	1,836	485016	2461174
2.12.2016	1,75	1,748	455956	2461080
2/19/2016	1,747	1,745	462562	2461211
2/26/2016	1,764	1,762	468542	2461152
3.4.2016	1,876	1,874	468548	2461196
3.11.2016	1,986	1,984	468555	2461239
3/18/2016	1,875	1,873	468561	2461283
3/25/2016	1,902	1,9	464882	2461326
4.1.2016	1,772	1,771	474170	2461345
4.8.2016	1,718	1,717	474174	2461368
4/15/2016	1,754	1,752	474318	2461390
4/22/2016	1,89	1,888	474322	2461413
4/29/2016	1,835	1,833	479447	2461489
5.6.2016	1,781	1,779	479465	2461605
5/13/2016	1,702	1,7	441214	2461721
5/20/2016	1,84	1,838	441232	2461637
5/27/2016	1,853	1,851	449610	2461761
6.3.2016	1,702	1,7	449634	2461897
6.10.2016	1,642	1,64	449658	2462032
6/17/2016	1,61	1,608	449682	2462168
6/24/2016	1,562	1,56	447746	2462303
7.1.2016	1,446	1,444	451851	2462427
7.8.2016	1,36	1,358	451872	2462541
7/15/2016	1,553	1,551	452290	2462652
7/22/2016	1,568	1,566	452309	2462763
7/29/2016	1,455	1,453	454273	2462865
8.5.2016	1,59	1,589	454289	2462956
8.12.2016	1,515	1,514	429152	2463447
8/19/2016	1,58	1,578	429168	2463538
8/26/2016	1,631	1,63	431098	2463645
9.2.2016	1,604	1,602	431090	2463599
9.9.2016	1,677	1,675	431082	2463553
9/16/2016	1,694	1,693	431074	2463506
9/23/2016	1,62	1,618	431066	2463460
9/30/2016	1,596	1,594	433453	2463473

10.7.2016	1,72	1,718	433457	2463497
10/14/2016	1,799	1,798	433461	2463520
10/21/2016	1,736	1,735	433465	2463544
10/28/2016	1,849	1,847	435165	2463586
11.4.2016	1,778	1,776	435177	2463654
11.11.2016	2,152	2,15	384699	2463722
11/18/2016	2,357	2,355	395485	2463801
11/25/2016	2,359	2,357	399648	2463861
12.2.2016	2,385	2,383	399255	2463496
12.9.2016	2,469	2,467	399261	2463531
12/16/2016	2,593	2,592	399268	2463566
12/23/2016	2,539	2,537	399275	2463601
12/30/2016	2,446	2,444	402996	2463591
1.6.2017	2,421	2,419	402988	2463548
1/13/2017	2,398	2,396	405075	2463504
1/20/2017	2,469	2,467	405066	2463462
1/27/2017	2,486	2,484	407659	2463426
2.3.2017	2,467	2,465	407661	2463436
2.10.2017	2,409	2,407	363532	2463446
2/17/2017	2,416	2,415	372215	2463456
2/24/2017	2,313	2,312	376104	2463488
3.3.2017	2,48	2,478	376137	2463650
3.10.2017	2,576	2,575	376170	2463812
3/17/2017	2,502	2,5	376203	2463974
3/24/2017	2,414	2,412	376236	2464335
3/31/2017	2,389	2,387	380988	2464454
4.7.2017	2,384	2,382	381007	2464546
4/14/2017	2,239	2,237	381191	2464638
4/21/2017	2,25	2,248	381211	2464730
4/28/2017	2,282	2,28	384939	2464792
5.5.2017	2,351	2,349	384944	2464815
5.12.2017	2,327	2,326	349054	2464638
5/19/2017	2,236	2,235	349059	2464660
5/26/2017	2,248	2,246	353768	2464696
6.2.2017	2,161	2,159	353787	2464783
6.9.2017	2,202	2,201	353806	2464871
6/16/2017	2,153	2,151	353826	2464958
6/23/2017	2,144	2,142	353845	2465046
6/30/2017	2,305	2,304	357258	2465096
7.7.2017	2,387	2,386	357263	2465121
7/14/2017	2,334	2,332	357347	2465145
7/21/2017	2,239	2,238	357353	2465170
7/28/2017	2,291	2,289	361528	2465195
8.4.2017	2,264	2,262	361534	2465221
8.11.2017	2,191	2,189	312184	2465247
8/18/2017	2,196	2,194	324394	2465273

8/25/2017	2,168	2,166	324365	2465300
9.1.2017	2,169	2,166	325239	2465289
9.8.2017	2,052	2,051	325435	2465468
9/15/2017	2,204	2,202	325430	2465448
9/22/2017	2,252	2,25	325425	2465427
9/29/2017	2,335	2,334	328882	2465467
10.6.2017	2,361	2,359	328902	2465554
10/13/2017	2,275	2,273	328922	2465641
10/20/2017	2,386	2,384	328941	2465727
10/27/2017	2,408	2,406	329644	2459827
11.3.2017	2,334	2,332	329680	2459985
11.10.2017	2,4	2,398	292840	2456641
11/17/2017	2,345	2,343	308286	2456822
11/24/2017	2,344	2,342	308302	2456959
12.1.2017	2,363	2,362	310425	2454474
12.8.2017	2,378	2,376	310420	2454256
12/15/2017	2,355	2,353	310416	2454237
12/22/2017	2,483	2,481	310412	2454219
12/29/2017	2,407	2,405	314035	2448208
1.5.2018	2,478	2,476	314035	2448209
1.12.2018	2,55	2,546	316716	2447009
1/19/2018	2,661	2,659	316716	2447009
1/26/2018	2,662	2,66	322166	2436211
2.2.2018	2,843	2,841	322161	2436192
2.9.2018	2,853	2,851	295684	2436173
2/16/2018	2,877	2,875	300215	2432066
2/23/2018	2,87	2,866	297846	2424242
3.2.2018	2,866	2,864	297887	2424402
3.9.2018	2,896	2,894	297929	2424562
3/16/2018	2,846	2,844	297970	2424723
3/23/2018	2,815	2,814	298012	2424883
3/30/2018	2,741	2,739	296395	2413031
4.6.2018	2,775	2,773	296322	2413060
4/13/2018	2,828	2,827	308229	2413079
4/20/2018	2,962	2,96	308277	2413218
4/27/2018	2,959	2,957	304579	2395460
5.4.2018	2,952	2,95	304602	2395528
5.11.2018	2,973	2,97	290054	2386966
5/18/2018	3,058	3,056	296104	2387035
5/25/2018	2,933	2,931	288986	2387103
6.1.2018	2,904	2,902	296172	2377872
6.8.2018	2,948	2,946	296217	2377998
6/15/2018	2,922	2,921	296261	2378124
6/22/2018	2,897	2,895	296305	2378250
6/29/2018	2,862	2,86	295992	2360377
7.6.2018	2,824	2,822	296037	2360504

7/13/2018	2,829	2,827	296154	2359766
7/20/2018	2,895	2,893	296199	2359893
7/27/2018	2,956	2,954	296622	2336876
8.3.2018	2,951	2,949	296639	2336925
8.10.2018	2,875	2,873	258449	2324391
8/17/2018	2,862	2,86	267171	2324540
8/24/2018	2,812	2,81	267189	2324589
8/31/2018	2,862	2,86	267464	2313202
9.7.2018	2,942	2,939	267465	2313204
9/14/2018	2,998	2,996	267466	2313206
9/21/2018	3,065	3,063	267467	2313208
9/28/2018	3,063	3,061	265763	2294210
10.5.2018	3,235	3,233	265769	2294227
10.12.2018	3,163	3,161	265775	2294245
10/19/2018	3,194	3,192	265781	2294215
10/26/2018	3,077	3,076	264095	2270399
11.2.2018	3,214	3,212	264108	2270436
11.9.2018	3,184	3,182	255606	2270420
11/16/2018	3,065	3,063	263716	2253085
11/23/2018	3,043	3,039	263727	2253117
11/30/2018	2,99	2,988	264547	2240551
12.7.2018	2,849	2,845	264567	2240606
12/14/2018	2,893	2,889	264587	2240661
12/21/2018	2,794	2,79	264607	2240717
12/28/2018	2,722	2,718	260887	2222517
1.4.2019	2,671	2,668	260849	2222412
1.11.2019	2,703	2,701	260811	2220219
1/18/2019	2,786	2,784	261168	2220115
1/25/2019	2,76	2,758	259354	2220012
2.1.2019	2,686	2,684	259314	2205713
2.8.2019	2,638	2,634	259274	2205604
2/15/2019	2,664	2,663	254819	2182201
2/22/2019	2,655	2,652	254779	2182092
3.1.2019	2,757	2,753	252449	2175420
3.8.2019	2,632	2,628	252470	2175479
3/15/2019	2,591	2,587	252492	2175537
3/22/2019	2,443	2,439	252513	2175596
3/29/2019	2,407	2,405	249157	2153308
4.5.2019	2,497	2,495	249207	2153443
4.12.2019	2,567	2,565	249260	2153409
4/19/2019	2,563	2,56	262007	2153544
4/26/2019	2,5	2,498	258659	2123954
5.3.2019	2,527	2,525	258739	2124129
5.10.2019	2,469	2,467	257102	2114444
5/17/2019	2,393	2,391	266380	2114569
5/24/2019	2,322	2,32	266461	2114744

5/31/2019	2,126	2,125	267697	2109785
6.7.2019	2,084	2,081	267777	2109957
6/14/2019	2,082	2,08	267857	2110084
6/21/2019	2,057	2,054	267937	2110256
6/28/2019	2,007	2,005	266427	2095393
7.5.2019	2,036	2,034	266454	2095448
7.12.2019	2,124	2,122	266685	2093984
7/19/2019	2,057	2,055	266716	2094051
7/26/2019	2,072	2,07	265728	2080700
8.2.2019	1,849	1,845	265731	2080704
8.9.2019	1,746	1,745	265734	2080710
8/16/2019	1,556	1,554	289608	2088920
8/23/2019	1,537	1,535	291712	2095130
8/30/2019	1,499	1,496	295006	2095164
9.6.2019	1,562	1,56	297554	2101169
9/13/2019	1,899	1,896	297580	2105826
9/20/2019	1,725	1,721	297606	2107683
9/27/2019	1,685	1,68	302345	2117130
10.4.2019	1,531	1,529	302408	2121485
10.11.2019	1,732	1,729	302407	2123085
10/18/2019	1,757	1,754	302406	2149188
10/25/2019	1,798	1,794	302405	2175491
11.1.2019	1,712	1,71	308578	2194318
11.8.2019	1,943	1,942	310038	2201529
11/15/2019	1,832	1,831	317309	2220361
11/22/2019	1,772	1,771	317323	2248498
11/29/2019	1,777	1,776	322057	2259853
12.6.2019	1,84	1,836	322136	2282196
12/13/2019	1,824	1,823	322172	2300678
12/20/2019	1,919	1,917	322208	2328862
12/27/2019	1,879	1,875	321591	2328933
1.3.2020	1,79	1,788	324301	2347714
1.10.2020	1,823	1,82	315612	2362635
1/17/2020	1,823	1,821	315605	2381020
1/24/2020	1,686	1,684	315598	2409108
1/31/2020	1,508	1,507	319329	2427880
2.7.2020	1,585	1,583	319315	2442621
2/14/2020	1,588	1,585	325396	2451688
2/21/2020	1,473	1,471	325382	2474060
2/28/2020	1,152	1,149	326323	2502624
3.6.2020	0,765	0,762	327906	2523031
3/13/2020	0,968	0,96	357666	2640771
3/20/2020	0,85	0,845	436318	2978372
3/27/2020	0,682	0,675	509228	3340832
4.3.2020	0,599	0,595	576918	3634386
4.10.2020	0,724	0,719	621255	3788858

4/17/2020	0,645	0,642	659309	3909352
4/24/2020	0,604	0,601	665596	3971419
5.1.2020	0,616	0,612	675810	4020191
5.8.2020	0,686	0,683	686628	4057268
5/15/2020	0,646	0,643	711258	4089331
5/22/2020	0,661	0,659	719915	4109512
5/29/2020	0,654	0,653	719393	4134356
6.5.2020	0,897	0,895	725316	4150409
6.12.2020	0,707	0,703	729159	4169340
6/19/2020	0,697	0,694	735883	4197404
6/26/2020	0,643	0,641	732150	4213220
7.3.2020	0,671	0,669	735426	4231355
7.10.2020	0,648	0,645	738129	4253229
7/17/2020	0,628	0,627	745867	4265878
7/24/2020	0,59	0,589	746156	4293563
7/31/2020	0,53	0,528	745463	4305651
8.7.2020	0,566	0,564	754625	4320093
8/14/2020	0,711	0,709	762621	4345544
8/21/2020	0,631	0,628	771901	4358559
8/28/2020	0,726	0,721	766933	4386637
9.4.2020	0,72	0,718	770951	4393621
9.11.2020	0,667	0,666	778237	4407005
9/18/2020	0,697	0,694	787290	4431523
9/25/2020	0,658	0,654	788868	4445477
10.2.2020	0,704	0,701	797112	4469848
10.9.2020	0,779	0,774	797937	4484978
10/16/2020	0,747	0,746	805291	4509778
10/23/2020	0,845	0,843	809323	4527186
10/30/2020	0,875	0,874	812404	4538087
11.6.2020	0,822	0,818	812450	4552731
11/13/2020	0,9	0,896	824797	4584423
11/20/2020	0,826	0,824	826697	4606580
11/27/2020	0,841	0,837	829664	4614410
12.4.2020	0,969	0,966	830650	4630538
12.11.2020	0,9	0,896	832286	4662841
12/18/2020	0,951	0,946	833243	4682881
12/25/2020	0,928	0,923	827914	4688916
1.1.2021	0,918	0,913	836876	4699421
1.8.2021	1,119	1,115	843174	4723733
1/15/2021	1,085	1,083	826150	4743552
1/22/2021	1,089	1,086	834222	4766107
1/29/2021	1,069	1,065	836802	4772074
2.5.2021	1,167	1,164	845658	4798901
2.12.2021	1,213	1,208	851747	4824057
2/19/2021	1,341	1,336	858715	4844574
2/26/2021	1,41	1,405	866624	

3.5.2021	1,57	1,566

Federal Reserve Bank of St. Louis

Date	Total Federal Debt	Total US Treasuries held by the Fed
2007-07-01	9007653	786658
2007-10-01	9229172	776570
2008-01-01	9437594	706296
2008-04-01	9492006	520016
2008-07-01	10024725	479158
2008-10-01	10699805	476367
2009-01-01	11126941	474972
2009-04-01	11545275	573745
2009-07-01	11909828	723569
2009-10-01	12311349	775355
2010-01-01	12773123	776608
2010-04-01	13201792	776835
2010-07-01	13561622	785670
2010-10-01	14025215	895235
2011-01-01	14270114	1185961
2011-04-01	14343087	1488714
2011-07-01	14790340	1646411
2011-10-01	15222940	1671434
2012-01-01	15606518	1660243
2012-04-01	15855037	1665291
2012-07-01	16066240	1649845
2012-10-01	16432730	1653312
2013-01-01	16771381	1729275
2013-04-01	16738320	1866165
2013-07-01	16738180	2002152
2013-10-01	17156119	2140136
2014-01-01	17601227	2259937
2014-04-01	17632606	2360108

2014-07-01	17824071	2426745
2014-10-01	18141444	2459731
2015-01-01	18152056	2460424
2015-04-01	18151998	2460307
2015-07-01	18150618	2461634
2015-10-01	18922179	2461699
2016-01-01	19264939	2461279
2016-04-01	19381591	2461702
2016-07-01	19573445	2463150
2016-10-01	19976827	2463604
2017-01-01	19846420	2463625
2017-04-01	19844554	2464741
2017-07-01	20244900	2465262
2017-10-01	20492747	2459216
2018-01-01	21089643	2434915
2018-04-01	21195070	2393594
2018-07-01	21516058	2333899
2018-10-01	21974096	2265915
2019-01-01	22027880	2198686
2019-04-01	22023283	2126587
2019-07-01	22719402	2093452
2019-10-01	23201380	2209436
2020-01-01	23223813	2482343
2020-04-01	26477241	3967128
2020-07-01	26945391	4332240